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The onset and expansion of the 2018 Martian Global Dust Storm from ground-based and VMC/MEx imaging

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Abstract

We present a study of the onset and expansion of the 2018 Martian Global Dust Storm (GDS 2018) using ground-based images obtained with small telescopes and Visual Monitoring Camera (VMC) Mars Express images obtained from May to August 2018. During this time period VMC observed south polar latitudes showing the expansion of the dust storm over the South polar cap. The storm outbreak occurred in Acidalia Planitia on 30 and 31 May 2018. From 1-8 June the storm expanded with mean velocities in the range 5-40 ms^{-1}. The dust reached the South Pole by 8 June but the penetration and propagation in this region was heterogeneous. During July 2018, we measured dust motions in the pole directed toward terminator with peak velocities up to 100 ms^{-1}. The dust reached peak altitudes of 60-70 km in other latitudes of the planet

1. Introduction

Mars Global Dust Storms (GDS), also referred as "planet encircling dust storms" represent a unique dynamical phenomena in terrestrial planet atmospheres [1]. They are unusual aperiodic events (in time and location). The onset of all confirmed GDSs occurred from Ls = 185° to 300°, during the "dust season" [1]. We present the analysis of the onset phase and expansion of the new GDS that occurred in 2018.

2. GDS 2018 onset and early expansion

We used ground-based images from the ALPO Japan [2] and PVOL [3] databases repositories (Figure 1) to study the onset and initial expanse phase. The storm initiated on 30 May 2018 (Martian Year MY 34, Ls = 184.9°) in Acidalia Planitia at latitude +31.7°±1 and west longitude 18°±5°W. From 30 May to 8 June, daily image series showed the storm expanding southwards along the Acidalia corridor with velocities of 5 ms^{-1}, and simultaneously progressing eastwards and westwards with horizontal velocities ranging from 5 to 40 ms^{-1}. By 8 June the dust reached latitude -55° penetrating in the South polar region, whereas in the North the dust progression stopped at latitude ~ +46° [4]. The growth of the storm one week after its outbreak was ~ $4.3x10^6$ km^2day^{-1}, slightly below the 2001 and 2007 cases [4].

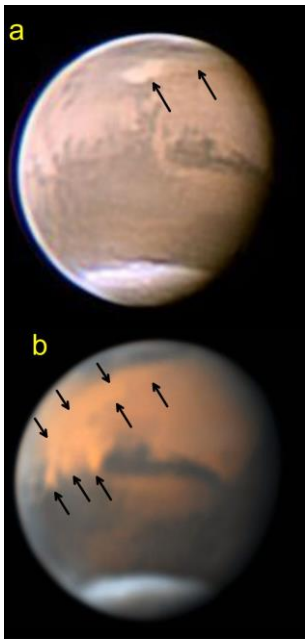

Figure 1: Ground-based images of the storm initial expansion: (a) 31 May 2018 (J. Rueck); (b) 5 June 2018 (D. Peach).

3. Dust penetration in the South Pole

The Visual Monitoring Camera on board Mars Express [6] imaged the expansion of the storm from June 18, onwards. Because of its polar orbit, good sequences of the South pole were obtained practically every day, allowing to study the propagation of the dust in this region (Figure 2).

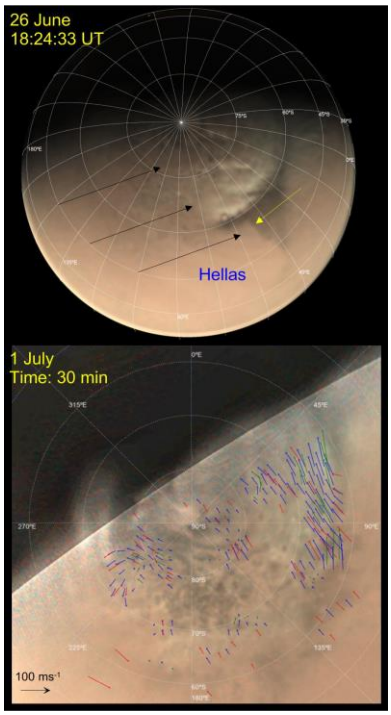

Figure 2: (a) VMC/MEx image showing the South pole partially covered by dust (marked by arrows); (b) Polar projection showing wind vectors measured using a feature tracking method comparing images separated by 30 minutes.

The dust expansion was inhomogeneous covering polar latitudes only partially. In most VMC images large water-ice clouds were present in the morning terminator. During July, the aerosols organized in large arc shaped bands (length ~ 2,000-3,000 km) surrounding the South Pole that penetrated in the night side. We estimated their altitude to be 10-30 km above surface. Tracking of dust features resulted in motions preferably directed towards the terminator with maximum velocities of 100 ms^{-1} (Figure 2, [5]). Finally, high-resolution limb images at equatorial and temperate latitudes showed that the dust from the storm reached top altitudes of 60-70 km.

4. Discussion

Two important features of the 2018 GDS event distinguish it from previous confirmed cases reported in years 1956, 1971, 1973, 1977A, 1977B, 2001 and 2007 [1]. First, starting at Ls = 185°, it is the earliest in the Martian seasonal cycle together with the 2001 case. Second, even though the Acidalia Planitia is a common place for regional dust storms, no other GDS has been seen to initiate in the northern hemisphere. All this makes this storm a singular event that deserves to be studied in detail to understand the mechanisms underlying a GDS outbreak.

Acknowledgements

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